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Life-cycles of tapeworms from lakes Gołdapiwo and Mamry Północne

Cykle rozwojowe tasiemców na jeziorach Gołdapiwo i Mamry Północne

The present work initiated on the lake Drużno (Jarecka, 1958a) is the continuation of studies on the life-cycles of tapeworms. It constitutes a fragment of collective investigations on the problem of the circulation of parasites in lakes (Wiśniewski, 1954, 1957, 1958) headed by the late Professor doctor W. L. Wiśniewski.

The period of investigations on the lake Gołdapiwo included two summer seasons (July, August, September) in 1954—1955 and 10 days lasting periods in May and November. On the lake Mamry Północne the period of investigation included two analogous seasons in 1956—1957. In those periods I studied on the two lakes the natural invasion of plankton crustaceans by larvae of tapeworms. Experimental contacts of the plankton crustaceans with eggs of tapeworms parasitizing fishes and birds were also attained.

Methods

The lake Gołdapiwo and Mamry Północne, contrary to the lake Drużno, possess a distinctly differentiated pelagic and littoral zones with specific communities of crustaceans. In connection with this it was necessary to conduct parallel studies of the naturally invaded *Crustacea* occurring in the pelagial and littoral whereby to the two different environments suitably adapted methods for the collection of samples had to be adapted.

The *Crustacea* were collected from the pelagial by the use of a 5 litres measuring Patalas' ladle. From the separate points of the pelagial I collected the *Crustacea* every time from 20 litres of water taken from 3 levels (from

underneath the surface, at the bottom and from half depth) at 2—3 meters distances. In particularly deep places the samples were collected at 4—5 levels. Each time the samples were taken from a different point to include the whole lake into investigations.

Littoral conditions (mosaic character of the environment, shallowness, abundance of vegetation) enabled to use only the qualitative method. The plankton was collected by the use of a plankton net attached to a rod. In this way it was possible to fish out crustaceans in very shallow and overgrown waters, which were the most interesting points of the littoral in view of the quantitative and qualitative occurrence of crustaceans and their natural invasion. Such places offered favourable conditions for contact of the intermediate and final hosts of tapeworms; they were, therefore, centres of natural invasions in the lake.

The choice of places for the collection of crustaceans was made on the basis of observations where the birds nestle and feed. In this way were found places of the natural contacts of the host and parasite.

Identification of species of the caught crustaceans and studies of the natural invasion were conducted exclusively on live material.

All *Crustacea* of every collected sample were studied with the exception of the early stages of copepodites (*Cladocera* of the lake Gołdapiwo were not studied).

To obtain live larvae of parasites in which the anatomical structure is best visible it was indispensable to apply the method of examination of live specimens. In addition it should be stressed that the differentiation of the species composition of *Copepoda, Ostracoda* and *Cladocera* is much easier to make on live material than on preserved specimens. In preserved *Crustacea* there is absent a number of characteristics specific to this species which enable to differentiate them even without the use of a microscope as, e.g., colour, general outline, mode of movement etc. Live crustaceans observed by the use of a microscope are transparent. Following the withdrawal of water from the slide they lie motionless on one side; in this position are very well visible diagnostic features (e.g., V and IV legs of *Copepoda*). After squashing the live crustaceans by pressing the cover glass the soft parts float and the chitin structures are still well visible.

The larvae of tapeworms found by me were examined in vivo.

The experimental part of my studies aimed to bring in touch mature eggs of tapeworms with the certain species of *Copepoda, Ostracoda* and *Cladocera.*

My observations proved that a condition to obtain a true result of an experimental invasion, both positive and negative, is above all the use in the experiment of mature, i.e., invasive eggs. The species of *Crustacea* submitted to experimental invasion should also remain under suitably good conditions at the moment of their contact with the eggs. The crustaceans transferred directly from the natural to the experimental environment may not eat

Table I

Natural invasion in examined *Crustacea* of Lake Gołdapiwo

	Crustacea species	Number of specimens examined	*Ligula* sp.	*Bothriocephalus claviceps* (Goeze, 1782)	*Proteocephalus percae* (O.F. Mull.)	*Proteocephalus* sp.	*Proteocephalus macrocephalus* (Crepl., 1825)	*Diplopostbe laevis* (Bloch, 1782)	*Hymenolepis paracompressa* Czapl., 1956	*Hymenolepis spiralibursata* Czapl., 1956	*Fimbriaria* sp.	*Dicranotaenia coronula* (Duj., 1845)	*Hymenolepis gracilis* (Zeder, 1803)	*Hymenolepis macrocephala* Fuhrm., 1913	*Diorchis nyrocae* Yamaguti, 1935	*Diorchis inflata* (Rud., 1819)	*Diorchis ransomi* Schultz, 1940	*Anomotaenia ciliata* (Fuhrm., 1913)	Total
Pelagic	1. *Cyclops scutifer* Sars	1189				2													2
	2. *Mesocyclops oithonoides* Sars	1014																	
	3. *Mesocyclops leuckarti* Claus	1715																	
	Copepodit of *Cyclops* sp.	4639				4													4
	4. *Eudiaptomus graciloides* Lill.	10230			40														40
Littoral	5. *Macrocyclops albidus* (Jur.)	3260	1	9				4	4	2	2								22
	6. *Macrocyclops fuscus* (Jur.)	583																	
	7. *Macrocyclops distinctus* (Richard)	165																	
	8. *Mycrocyclops viridis* (Jur.)	452																	
	9. *Acanthocyclops vernalis* (Fisch.)	195																	
	10. *Cyclops insignis* Claus	169					4												4
	11. *Mesocyclops crassus* (Fisch.)	112																	
	12. *Eucyclops macrurus* (Sars)	285																	
	13. *Eucyclops macruroides* (Lill.)	1483																	
	14. *Eucyclops serrulatus* (Fisch.)	148																	
	15. *Cypridopsis vidua* (O.F. Müll.)	2821										5				4			9
	16. *Cyclocypris laevis* (O.F. Müll.)	7541									3	21			2		54		80
	17. *Cyclocypris ovum* (Jur.)	482																	
	18. *Notodromas monacha* O.F. Müll.	1224											2						2
	19. *Dolerocypris fasciata* O.F. Müll.	19																	
	20. *Simocephalus expinosus* (Koch.)	140																98	98
	21. *Ceriodaphnia reticulata* Sars	50																	
	Total	37914	1	9	40	6	4	4	4	2	5	21	5	2	2	4	54	98	261

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the eggs. In the experiments the mono-cultures of certain species of *Crustacea*, previously adapted to experimental conditions, were used. The eggs of tapeworm were derived, if it was possible, from one single worm.

Morphological determination of the maturity that is the invasiveness of eggs renders some difficulties, because immature eggs possess already a developed oncosphere provided with 3 pairs of embryonic hooks.

My observations and experiments proved that a mature egg must be provided with a completely developed external egg covering which is in the majority of the described eggs a very thin, transparent membrane. I determined the maturity of eggs by observing them for some time in water. In case the external egg shell was not fully developed various impurities present in water adhered to it and soon could be observed processes of egg decaying. Eggs with mature external egg shell, however, can remain in water over 10 days with no sign of any destructive processes taking place.

Material

During the 2 seasons I examined the *Crustacea* of the lake Gołdapiwo in 175 twenty litres samples collected from 58 points of the pelagial. In the analogous seasons I examined also the *Crustacea* in 131 samples collected from 45 points on the lake Mamry Północne. The examined *Crustacea* of the lake Gołdapiwo littoral were collected from 46 places, those of the Mamry Północne — from 50.

In the pelagial and littoral of both lakes there were numerous species of *Copepoda, Ostracoda* and *Cladocera* as listed in Tables I and II.

In the examined *Crustacea* of both lakes I found 372 larvae of 26 species of tapeworms parasitizing as mature forms in fishes and birds. They were procercoids of 2 species, cysticercoids of 21 species and larvae of 3 species of *Proteocephalidae* (Table I and II). In the species from the pelagial zone there were only larvae of 2 species of *Proteocephalidae: Proteocephalus percae* (O. F. Müll.) and *Proteocephalus* sp. The larvae of the remaining tapeworms occurred in the littoral crustaceans; they were larvae of the tapeworms of birds and fishes, nutritionally connected with the littoral.

Descriptive and experimental part

The description of the eggs, larvae and life-cycles of *Bothriocephalus claviceps* (Goeze, 1782), *Anomotaenia ciliata* (Fuhrm., 1913), *Hymenolepis furcifera* (Krabbe, 1869), *Orlovilepis megalops* (Creplin, 1829), which are a part of the material collected in the examined lakes is presented in separate publications (Jarecka, 1958 b, c, 1959). The description of the remaining specimens is given in the present publication.

1. *Ligula* sp.

In the examined material (Table I, II) I found two procercoids of *Ligula* sp. One of them was in the body cavity of *Macrocyclops albidus* of the littoral sample of the lake Gołdapiwo, the second one was in the pelagial *Eudiaptomus graciloides*. The results of the experimental studies on the developmental specificity of species of the genus *Ligula* will be presented in a separate publication.

2. *Proteocephalus percae* (O. F. Müll.).

Table I, Fig. 1, 2, 3.

I found the larvae of *P. percae* in pelagial samples of plankton in *Eudiaptomus graciloides*. In the lake Gołdapiwo there were in 10,230 examined *E. graciloides* 40 invaded with *P. percae* and in the lake Mamry Północne there were 7 invaded in 7,638 examined (Table I, II).

The diagnosis of larvae was based on the method of the morphological comparison of theirs scolex with that of the mature tapeworm. According to Kozicka's data, who studied at the same time the parasites of fishes, on the mentioned lakes *P. percae* occurred numerously in *Perca fluviatilis* L.

The scolex of larvae found in *E. graciloides* does not differ from the mature scolex of *P. percae*. A common and characteristic feature was the presence of the well developed V (fifth) sucker. It measured both in the larvae and in tapeworms 33 μ what constitutes 1/2 of the size of the remaining suckers.

I found larvae in the course of the whole investigation period. However, in July the larvae were still young and some of them possessed still at that time cercomeres and not completely developed suckers. In August, October and November they were completely developed, and they occurred only in spring generation of *E. graciloides*. This is an indication of the seasonal character

of life-cycle, similar to that described by Wegner (1915) in *Proteocephalus torulosus* (Batsch, 1786).

According to Kuczkowski (1925) the experimental intermediate host is *Cyclops strenuus*, and according to Wierzbicka (1957) — *Cyclops vicinus* Ulj. and *Cyclops colensis* Lillj.

The larvae from natural invasion collected by me were of the shape represented in Fig. 2. The length of the larva together with the scolex is 630 μ, width 230 μ. The four round suckers, having a distinct marginal musculature, are 66 μ in diameter. The V (fifth) sucker is similar to the one described but is half its size. In the body of larva there are visible the main excretory canals which have a wavy course (more or less marked depending on the contraction) on the lateral sides of the body. The terminate in the posterior part of the body in the excretory vesicle of a pipe-like shape. Along those canals and their small lateral branches there are the calcareous corpuscles. In some larvae in various parts of the body I observed the presence of single embryonic hooks.

The larvae after the removal from the body cavity of the intermediate host live and keep in motion for several hours. In such larvae I observed fairly often invagination of the scolex towards the interior part of the body. In such a case they appeared in the form of the cysticercus type (Fig. 3). After the invagination the larvae ceased to move. I had never observed any case of a return to the evaginated form, which they always have in the intermediate host. Such an invagination was also observed by Wagner (1915) in the larvae of *Proteocephalus torulosus*.

The mature *P. percae* immediately after the removal from the intestine of a fish discharges into the water the eggs present in the uterus. The structure of the eggs is similar to the eggs of *Hymenolepididae*. They contain formed round oncosphere with three pairs of embryonic hooks. The oncosphere is surrounded by its own thin membrane and by the internal egg shell. The internal egg shell is about 8 μ thick and contains some glittering granules. The oncosphere, surrounded by the internal egg shell, occupies in the egg immersed in water the nether position, thus the external egg covering plays the role of a parachute. This is undoubtedly an adaptation of the shape of egg to the contact with the intermediate host, which in this case occurs in the pelagial zone of the lake.

Herde (1938) observed in the eggs of *Ophiotaenia perspicua* La Rue the phenomenon of an active extrication of the on-

Table II

Natural invasion in examined *Crustacea* of Lake Mamry Północne

	Crustacea species	Number of specimens examined	*Ligula* sp.	*Bothriocephalus claviceps* (Goeze, 1782)	*Protocephalus percae* (O.F. Müll.)	*Protocephalus* sp.	*Diplopostha laevis* (Bloch, 1782)	*Hymenolepis paracompressa* Czapl., 1956	*Hymenolepis aequabilis* (Rud., 1810)	*Hymenolepis furcifera* (Krabbe, 1869)	*Dicranotaenia coronula* (Duj., 1845)	*Orlorileptis megalops* (Crepl., 1829)	*Hymenolepis gracilis* (Zeder, 1803)	*Diorchis infiata* (Rud., 1819)	*Diorchis ransomi* Schultz, 1940	*Drepanidotaenia bisaccutina* Szpot., 1931	Total
Pelagic	1. *Mesocyclops oithonoides* Sars	861															
	2. *Mesocyclops leuckarti* Claus	1265															
	3. *Eudiaptomus graciloides* Lill.	7638	1		6	1											8
	4. *Euratemora* sp.	1150															
	5. *Heterocope* sp.	209															
	6. *Daphnia cucullata* Sar	458															
	7. *Diaphanosoma brachyurum* (Levin)	665															
	8. *Leptodora cindti* (Focke)	98															
	9. *Bythotrephes longimanus* Leydig	33															

Littoral	10. *Macrocyclops albidus* (Jur.)	426		2			3	3									8
	11. *Macrocyclops fuscus* (Jur.)	366															
	12. *Macrocyclops distinctus* (Richard)	74															
	13. *Acanthocyclops viridis* (Jur.)	516														52	52
	14. *Acanthocyclops bicuspidatus*(Claus)	22															
	15. *Mesocyclops crassus* (Fisch.)	509															
	16. *Eucyclops macrucus* (Sars)	251															
	17. *Eucyclops macruroides* (Lill.)	218															
	18. *Eucyclops serrulatus* (Lill.)	98															
	19. *Eudiaptomus gracilis* Sars	101															
	20. *Simocephalus expinosus* (Koch)	1220															
	21. *Eurycercus lamellatus* (O.F.M.)	964								1							1
	22. *Ceriodaphnia reticulata* Sars	317															
	23. *Sida crystallina* (O.F.M.)	1081															
	24. *Scapoleberis mucronata* (O.F.M.)	129															
	25. *Peracentha truncata* (O.F.M.)	175															
	26. *Polyphemus pediculus* (L.)	266															
	27. *Bosmina* sp.	70															
	28. *Cypridopsis vidua* (O.F.M.	852											1	5			6
	29. *Cyclocypris laevis* (O.F.M.)	1690							12		3				21		36
	30. *Notodromas monacha* (O.F.M.)	1487															
	31. *Dolerocypris fasciata* (O.F.M.)	60															
	32. *Cypris pubera* (O.F.M.)	280										1					1
Total		23652	1	2	6	1	3	3	12	1	3	1	1	5	21	52	112

cosphere from the internal egg shell to the space surrounded by external egg shell. Analogous phenomenon was observed in the oncospheres present in the eggs of *P. percae*.

The size of the eggs of *P. percae* is on average 120 μ, that of the oncospheres 22 μ. The oncospheres together with the internal egg covering have a diameter of 40 μ, the embryonic hooks are 0.7 μ in length.

3. *Proteocephalus* sp.

Table II, Fig. 6.

In *Cyclops scutifer* Sars and in its copepodites from the Gołdapiwo lake I found 6 larvae of *Proteocephalus* sp. (Table I). These larvae differ from the larvae of *P. percae* by the absence of the V (fifth) sucker and by smaller dimensions of the body. Their size is 370 × 185 μ. The diameter of four suckers of the scolex is 50 μ. The course of the excretory canals is as in *P. percae*.

I have found on the lake Mamry Północne only one larva without the V (fifth) sucker in *E. graciloides*. *Cyclops scutifer* did not occur.

4. *Proteocephalus macrocephalus* (Creplin, 1825).

Table II, fig. 5.

According to Kozicka, who elaborated in our team the parasites of fishes, *P. macrocephalus* occurred numerously in *Anguilla anguilla* (L.) particularly on the lake Gołdapiwo.

The larvae which I could morphologically compare with mature *P. macrocephalus* I found only in *Cyclops insignis* Claus.

Cyclops insignis occurred in the course of my investigations on the lake Gołdapiwo in autumn (November) in shallow, marshy spots of the littoral.

In the total number of 169 *C. insignis* examined in November four were invaded. The larvae from *C. insignis* in comparison with the larvae of the above described species are very large. They are 1300 μ in length, and 400 μ in width. The four round suckers of the scolex are small in relation to its size. Their diameter is 53 μ. The V (fifth) sucker is absent. The excretory canals run along the lateral sides of the body and terminate at the posterior part in the pipe-like excretory vesicle. Before the scolex they unite and give off branches. The calcareous corpuscles form aggregates along the excretory canals and their lateral branches.

P. macrocephalus, similarly to *Bothriocephalus claviceps* (Goeze, 1872) with which it occurs in the eel have their intermediate hosts among the littoral species of *Copepoda* (Jarecka, 1959). Natural invasion indicates the presence of specificity in relation to the species of the intermediate host. However whether it is a specificity of a physiological nature can be proved only by experimental studies. In the course of my studies I did not have an opportunity to perform an experimental invasion of various species of *Copepoda*, because I had no mature eggs. It is most likely that in this case, similarly as in other species of *Proteocephalidae*, there appears a seasonal maturation of eggs.

5. *Hymenolepis aequabilis* (Rudolphi, 1810).

Table IV, Fig. 13, 14, 15.

In the littoral samples of *Crustacea*, caught in the environment of nests and on places of feeding of *Cygnus olor* (Gm.), I found the cysticercoids in *Cyclocypris laevis* (O. F. Müll.), which I identified with the cysticercoids of *H. aequabilis*, obtained from an experimental invasion.

I found an adult form of this tapeworm in a young *Cygnus olor* on the lake Drużno. I contacted with the eggs first of all the *Cyclocypris laevis*, because in this species I found in the natural invasion cysticercoids of a scolex similar to that found in the adult form. After 12 days I obtained a 100% invasion. The invaded *Cyclocypris laevis* contained in their body cavity 2—5 developed cysticercoids of *H. aequabilis*. The obtained cysticercoids did not differ from the cysticercoids collected in places of natural contacts of *C. laevis* with *Cygnus olor*. In the lake Mamry Północne there were 12 *C. laevis* invaded (Table II) out of 1690 examined.

The cysticercoid of *H. aequabilis* possesses a cyst of the size 180 × 170 μ. The cercomer is short. The cavity of the cyst is filled by the scolex surronded by the internal covering which contains numerous calcareous corpuscles. The scolex is armed with four round suckers with muscular edges. The diameter of suckers 66 μ. There are 10 hooks, 29.7 μ in length. The handle of the hook is short, but the guard is almost as long as the blade and is provided with a shovel-like transversal thickening. The hooks of the cysticercoid do not differ from the hooks of the adult tapeworm.

The eggs of *H. aequabilis* are of an oval shape, the size 59 × 36 μ. In the centre of the egg there is an oncosphere of an oval form, provided with three pairs of embryonal hooks. The size of the oncosphere 29 × 16.5 μ. The internal egg covering is of a spindle-like form and its terminal parts turned in diverse directions. Between the membrane of the oncosphere and the internal wall of the internal egg covering there appears a small space filled with a liquid. This creates an apparent picture of the presence of a larger number of egg coverings. The embryonal hooklets are 1 μ in length.

6. *Drepanidotaenia bisacculina* Szpotańska, 1931.

Table IV, Fig. 16, 17.

I found the cysticercoids of *D. bisacculina* in the littoral samples of *Crustacea* from the lake Mamry Północne collected in places most commonly visited by *Cygnus olor*. These larvae showed a marked specificity in relation to the species of the intermediate host, because it occurs only in *Acanthocyclops viridis* (Jur.) In places of common contacts with the swan *A. viridis* was in 100% of cases invaded, even when its occurrence was not numerous and all other species of *Crustacea* caught in its company did not show invasion.

According to Joyeux et Baer (1950) the experimental intermediate host of *D. bisacculina* is *Macrocyclops fuscus* Jur. (no experiments were conducted on other species of *Crustacea*). In my material *M. fuscus* did not show a natural invasion, though it occurred in samples together with invaded *A. viridis*. This would indicate that the developmental specificity of *D. bisacculina* is not of a physiological nature but that it is the result of the biological properties, in the given case that of those two species of *Copepoda*. Most probably *M. fuscus*, as a predatory species, under natural conditions does not consume eggs of *D. bisacculina*, but artificially contacted with the oncospheres presents no physiological hindrance to the development.

The cysticercoids found in my material from natural invasion and the cysticercoids of *D. bisacculina*, presented on the photograph by Joyeux et Baer (1950) in their publication, fundamentally do not differ. There are 10 hooks. Their length in my material is 46 μ, in theirs — 40 μ. The disagreement in the publication of Joyeux et Baer (1950) concerning the description of the scolex

of the cysticercoid and tapeworm, of which the cysticercoids originate, is most probably the result of quotation by the authors of the description of Szpotańska, according to whom *D. bisacculina* possesses 8 hooks, 30—32 μ in length. However, it is my opinion based on a large comparative material (Jarecka, 1958a) that it is very unlikely that the scolex of the cysticercoid should be provided with larger hooks than its mature form, and that the number of hooks in the cysticercoid and the tapeworm should not be the same.

I found the adult tapeworm of *D. bisacculina* in a young *Cygnus olor* from the lake Drużno. The accidentally found dead bird contained in the intestines a large number of tapeworms. Deprived of the intestinal contents they occupied the 1/3 volume of the intestine. The remaining species of tapeworms I classified as *Hymenolepis aequabilis* (Rud., 1810) and *Drepanidotaenia nyrocae* (Yam., 1935). The number and size of hooks of the adult *D. bisacculina* were the same as in the above described cysticercoids.

Although the cysticercoid of *D. bisacculina* was the most numerous larva among the larvae found in the lake Mamry Północne, its adult form did not occur in any of the ducks examined at that time. This points to the specificity also towards the final host. Unfortunately *Cygnus olor* was not examined in view of the fact that it is protected by the law.

The cystivercoid of *D. bisacculina* differs from the cysticercoid of *D. lanceolata* (Bloch) described by Ruszkowski (1932), mainly by the number and dimensions of the hooks. Similar, however, is the shape of the cysts, and in both cases the presence of an extremely long cercomer. The cercomer of *D. bisacculina* is 8—10 mm in length.

7. *Hymenolepis macrocephala* Fuhrm., 1913.

Table III, Fig. 7, 8, 9.

I obtained the cysticercoids of *H. macrocephala* from an experimental invasion in *Notodromas monacha* O. F. Müller. The species of *Copepoda (Macrocyclops albidus, M. fuscus, Acanthocyclops viridis, Eucyclops macruroides)* digested the eggs of *H. macrocephala* and the oncospheres in none of the listed species passed to the body cavity. However, in *Ostracoda* species, as for instance in *Cypridopsis vidua,* numerous oncospheres passed to the body cavity, but did not find there conditions for their deve-

lopment. I found developed cysticercoids in *Notodromas monacha* and in 10% of the invaded *Cyclocypris laevis*. In the examined material from the natural invasion I found the cysticercoids of this species also in *N. monacha* in a sample collected from one of the small bays of the lake Gołdapiwo (Table I). The adult form occurred on the examined lakes in *Anas platyrhynchos* L.

The eggs of *H. macrocephala* are of an oval form and their external egg covering is like a disk flattened. The size of the eggs is within the limits 66 — 73 × 46 — 56 μ. The external covering is a very thin membrane difficult to observe. The internal egg covering, however, is relatively little transparent in view of the presence in it of a large number of small glittering granules (may be that they are formed by droplets of fat). The oncosphere is also of an oval shape and measures 33 × 16.5 μ. The embryonal hooklets are 0.66 μ in length. The oncosphere together with the internal egg covering measures 54 × 36 μ.

The cysticercoid of *H. macrocephala* has a pear-like cyst which measures 235 × 210 μ. The cercomer surpasses somewhat the length of the cyst. The cyst is provided with thin walls, the cavity of the cyst is filled with the large scolex, surrounded by the internal coat of the scolex. The musculature of the suckers not well visible. The diameter of the suckers is about 85 μ. There are 8 hooks of a shape as in the mature tapeworm. The length of the hooks is fairly variable, fluctuates within the limits 50—60 μ.

8. *Hymenolepis sacciperium* Mayhew, 1925.

Table III, Fig. 10, 11, 12.

The tapeworm with mature eggs was found by me in *Nyroca fuligula* from the lake Mamry Północne. I contacted the obtained eggs with a culture of *Macrocyclops albidus, Cypridopsis vidua* and *Cyclocypris laevis*. The cysticercoids developed in 45% of the invaded *Cyclocypris laevis* and the intensity was 1—2. The development of the cysticercoids lasted 30 days.

In natural invasion of the examined material the cysticercoids of *H. sacciperium* did not occur. I suppose that under natural conditions this tapeworm possesses a specific intermediate host. The result of the experiment shows only, that the intermediate host should be looked for among *Ostracoda*.

The eggs of *H. sacciperium* are provided with a thick, brown external egg membrane of a functional character of a shell. The shape of

eggs is spherical, their diameter 76 μ. The oval oncosphere present in the centre of the egg measures 39 × 33 μ. The embryonal hooklets are 1 μ in length. The oncosphere is surrounded by a thin proper membrane and by the internal egg covering. The internal egg covering is in the majority of eggs, originating from the same tapeworm, of an irregular shape (Fig. 10) resembling that of pressed paper. A smaller number of those eggs were provided with this membrane in the form of a more delicate capsule (Fig. 10). Between its internal edge and the membrane of the oncosphere, above its peak, there were spaces in which were concentrated glittering granules (droplets). The eggs of *H. sacciperium* are from their general outline and character similar to the described by me (Jarecka 1958, c) eggs of *Hymenolepis megalops* (Creplin, 1829). The intermediate host of *H. megalops* is *Cypris pubera* O. F. Müll. May be that in view of the similar character of the eggs under natural conditions the intermediate host is the same *Ostracoda* species.

The cysticercoids of *H. sacciperium*, obtained experimentally in *Cyclocypris laevis*, measure 210 × 160 μ. The cercomer does not surpass the length of the cyst. The scolex is provided with four oval suckers, 63 × 53 μ in size. On the rostellum there is a crown of small hooklets, over 20 in number, 12 μ in length. The internal coat of the scolex contains calcareous corpuscles.

9. *Hymenolepis compressa* (Linton, 1892).

Table VII, Fig. 27.

I had only once a small number of eggs of *H. compressa*. After getting them in touch with *Macrocyclops albidus*, *Acanthocyclops viridis* and *Mesocyclops leuckarti* I found on the 11th day 100% invasion of *M. albidus* at the intensity 5 to 13 cysticercoids in one specimen. High mortality rate of *M. leuckarti* made impossible to determine the percentage and intensity of their invasion. On the tenth day there remained alive only 3 *M. leuckarti*, of which 2 contained one cysticercoid each. *Acanthocyclops viridis* did not show any invasion.

The cysticercoid of *H. compressa* is of the same shape and size as the cysticercoid of *H. paracompressa* Czapliński, 1956, described from the lake Drużno (Jarecka, 1958 a). The hooks measures 50—53 μ; their shape is the same as of the tapeworms from the definitive host.

The eggs of *H. compressa* are larger than those of *H. paracompressa* described by Jarecka (1958 a). The diameter of eggs is 140 to 155 μ. The slightly oval oncosphere occupies in the egg the central position. Its size is 36 × 33 μ. The embryonal hooklets are 0.9 μ in length. The diameter of the internal egg covering is 105 μ. Between the internal edge of the internal egg covering and the membrane of the oncosphere there is a small space filled up with a liquid, what creates a seeming picture of the presence of a larger number of envelopes.

The external egg covering is a very elastic membrane.

10. *Hymenolepis abortiva* (Linstow, 1904).

Table VII, Fig. 26.

In one *Anas platyrhynchos* from the lake Mamry Północne I found over 10 mature *H. abortiva*. Only the last segment contained mature eggs sticked in a packet of a horse-shoe form. After staying in water for about 15 minutes, or following slight mechanical pressure on the mature segment, the packet of eggs liberated itself and remained in water.

A packet of eggs of *H. abortiva* contained over 10 permanently together united eggs. Each egg of the packet contains an oncosphere surrounded by three membranes: membrane of the oncosphere proper, external and internal egg coverings. The eggs of a packet have the edges of the external egg covering stuck together similarly as in the threads of *Fimbriaria fasciolaris* (Pallas, 1781) described by Jarecka (1958 a). Linstow reported that from a mature segment of *H. abortiva* the whole uterus with the eggs falls out.

The oncospheres of the *H. abortiva* eggs are of a spherical shape, their diameter is 33 μ. The size of the separate eggs in the packet is on the average 66 μ, that of the internal egg covering 45 μ.

The oncosphere is provided with three pairs of embryonal hooklets, of which the middle pair is of a different shape than the remaining two. The two hooklets of the lateral pair show also differences between themselves. The shape of the embryonal hooklets of *H. abortiva* is the same as in *Paricterotaenia porosa* (Rud., 1810), shown in the Fig. 23, 24. The middle pair of hooklets 13 μ, lateral 16.5 μ.

Packets of *H. abortiva* eggs were given to eat to three *Gammarus* sp. After three days two of them died and the examination

proved the presence in them of numerous spherical oncospheres. The last *Gammarus* died on the 10th day; it contained numerous (about 30) cysticercoids not yet developed into cysts. Unfortunately, this *Gammarus* was not fresh, therefore also the larvae were affected by the process of decay. I found only in some scolices the presence of already developed hooks of the shape and size as in the mature tapeworm.

11. *Diorchis stefańskii* Czapliński, 1956.

The eggs and cysticercoids were described in the earlier publication (Jarecka, 1958). Continuing experimental studies on the life-cycle of this species I obtained positive result of invasion of *Dolerocypris fasciata* O. F. Müll. On the 11th day following their contact with the *D. stefańskii* eggs I found the cysticercoids in all the invaded individuals, 5 to 25 in number in one specimen.

Parallelly invaded *Notodromas monacha* O. F. Müll. showed negative results. The oncospheres, after reaching the body cavity did not find conditions for the development similarly as in *Cypridopsis vidua* (Jarecka, 1958).

12. *Hymenolepis gracilis* (Zeder, 1803).

From studies conducted on the lake Drużno (Jarecka, 1958) it was proved that the natural and experimental host of this species is *Cypridopsis vidua.*

In natural invasion of the lakes Gołdapiwo and Mamry Północne the cysticercoid of *H. gracilis* occurred also in *Cypridopsis vidua* (Table I, II) I obtained, however, in experimental invasion the cysticercoids in *Dolerocypris fasciata.* On the 10th day following the contact with the eggs I found a 100% invasion, the intensity of the invasion was 5 to 20 cysticercoids.

13. *Dicranotaenia coronula* (Duj., 1845).

In the examined material, similarly as on the lake Drużno (Jarecka, 1958) the cysticercoids of. *D. coronula* were found in *Cyclocypris laevis* (Table I, II).

Continueing experimental studies I obtained cysticercoids of *D. coronula* in *Dolerocypris fasciata.* The development of the cysticercoids lasted 10 days, the intensity of invasion reached 8 to 24 cysticercoids in one specimen.

14. *Aploparaksis furcigera* (Rudolphi, 1819)

Table VI, Fig. 22.

Harper (1930) described the *A. furcigera* cysticercoid from a natural invasion of *Lumbriculus variegatus* Müll. He states that it is similar to the *Aploparaksis crassirostris* cysticercoid described by Mrazek (1907, 1916), in which the cercomer forms an additional envelope surrounding the cyst.

In the course of my studies I found mature eggs of *A. furcigera*, described them, and invaded experimentally *Oligochaeta*.

From the mature segments of *A. furcigera* are liberated into water not single eggs, but packets of eggs. The packets contain 2, 3, 4, 5 up to 9 oncospheres, whereby every one of them is provided with its own membrane and an internal egg covering. However, the external egg covering is common to the whole packet (Fig. 22).

The shape of the oncosphere is spherical, its diameter is 36 μ. The size of the internal egg covering is 70 μ. The size of the packet depends on the number of eggs forming it. The embryonal hooklets are 1 μ in length.

On the 19th day following the contact of the packets with *Oligochaeta* (3 *Limnodrilus* sp.) I found the developed cysticercoids in every body cavity of the middle segments, 4 to 6 in number.

The obtained cysticercoids did not differ from the cysticercoids described by Harper (1930). The rostellar hooks were the same as in the mature tapeworm.

I observed in the course of the development of the larvae in the body cavity of *Oligochaeta* that the „cercomer" capsule of the cyst is formed very early and that the formation of the scolex and the cyst takes place already in the space enclosed by this capsule.

15. *Tatria acanthorhyncha* (Wedl, 1855).

Table V, Fig. 18, 19, 20, 21

I found in one *Podiceps griseigena* Bodd. examined from the lake Mamry Północne over 10 small individuals of *T. acanthorhyncha*. The last segment of those tapeworms contained mature eggs. Touching the segment slightly caused it separation from the strobila.

The *T. acanthorhyncha* eggs are of a spherical shape, their size is 130 μ. In the middle of the egg there is the oncosphere of a triangular shape. The oncosphere is provided with three pairs of embryonal hooklets, 1 μ in length. There are also two structures of a glandular form filled with granules. The oncosphere is surroun-

ded by its own membrane and by the internal and external egg coverings. The internal one shows a reticular structure; its diameter is 90 μ. The external egg covering is formed by a thin transparent membrane. The oncosphere measures 39 × 33 μ.

A mature segment contains only several, at the most over 10 eggs. I did not notice spontaneous liberation of eggs from mature segments. I suppose that the whole segment plays here the role of a packet and can be eaten as the whole by the intermediate host (Fig. 18). I succeeded to collect several mature segments and to contact them with 10 *Macrocyclops albidus.*

On the 20th day following the contact I found in the body cavity of *Macrocyclops albidus* the developed cysticercoids, 1 to 3 in number in one specimen.

The cysts of the obtained cysticercoids have the shape of an apple. The cyst is 120 μ in length, 150 μ in width. The cercomer is several time longer than the cyst and is in its aterior part dilated. The embryonal hooks are located in the terminal part of the cercomer. The scolex fills up the interior of the thin-walled cyst and is surrounded by internal coat which contains calcareous corpuscles. On the scolex there are four spherical distinctly muscular suckers of the diameter 38 μ. On the elongated rostellum appear very small, irregular embryonal hooklets, similarly as in *Echinorhynchotaenia biuncjata* Joyeux et Gaud, 1945.

The experimentally obtained cysticercoids were not armed with rostellar hooks. The tapeworms, however, of which I collected the eggs for the experiments, had on the rostellum 12 hooks, 18 μ in length (Fig. 21). I did not notice any small hooklets, because they were lost in the course of the removal of the tapeworms from the intestine.

The described cysticercoid is not similar to the cysticercoid of *T. acanthorhyncha* described by Linstow (1892) from a natural invasion of *Agrion puella.*

The way of the life-cycle of the tapeworms of the genus *Tatria* is obscure and requires further investigations into experimental and natural invasion.

16. Cysticercoids of *Hymenolepis spiralibursata* Czapliński, 1956, *H. paracompressa* Czapliński, 1956, *Diploposthe laevis* (Bloch, 1782), *Fimbriaria fasciolaris* (Pallas, 1781), *Diorchis nyrocae* Yamaguti, 1935, *D. inflata* (Rudolphi, 1819), *D. ransomi* Schultz, 1913, occurred in natural invasion of the lakes

Gołdapiwo and Mamry Północne in the same species of *Crustacea* (Table I, II) as on the lake Drużno (J a r e c k a, 1958 a).

17. *Paricterotaenia porosa* (R u d., 1810).

Table VI, Fig. 23, 24, 25.

The *P. porosa* eggs and the oncospheres present in them are gigantic in comparison with the eggs and oncospheres of other species of tapeworms. The diameter of eggs in water attains 500 to 800 μ, that of the oncosphere 95 μ, that of the internal egg covering 120 to 160 μ.

The oncosphere is provided with three pairs of embryonal hooklets. The medium pair is of a shape as shown in Fig. 24, their length is 30 μ. In the lateral pairs one of the hooklets is thick, the other is thin, they are 33 μ in length (Fig. 25).

The same differentiation of the shape of the embryonic hooklets I observed only in the oncospheres of *H. abortiva*, although they are there considerably smaller. The egg, oncosphere and embryonal hooklets of *P. porosa* are of exceptionally large dimensions.

Experimental contact of eggs of *P. porosa* with *Copepoda* and *Ostracoda* gave negative results. *Copepoda* refused to eat the eggs but some species of *Ostracoda* digested the eaten eggs.

In *Gastropoda* and in the *Cyprinidae* fry only the egg shells are digested but the oncospheres together with the membrane of the oncosphere passed the alimentary tract undigested.

18. Eggs of *Diorchis* sp.

Table VII, Fig. 28.

In *Nyroca marila* from the lake Mamry Północne I found several mature *Diorchis* sp., the eggs of which have an interesting shape of the external egg covering. The general outline of those eggs shows a similarity to the eggs of *Diorchis nyrocae* Y a m a g u t i, 1935, described by J a r e c k a (1958 a) with the difference that the external egg covering appears here in a branched form.

The oncosphere of an oval shape is surrounded by its own membrane and by the internal and external egg covering of a shape as shown in Fig. 28. The size of the oncosphere is 36 × 13.5 μ, that of the internal egg shell 80 × 22 μ. One branch of the external egg covering is about 300 μ in length, the size of the embryonal hooklets is 0.7 μ.

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Fig. 1. Eggs of *Proteocephalus percae* (O. F. Müll.); Fig. 2. Larva of *Proteocephalus percae* (O. F. Müll.); Fig. 3. Larva of *P. percae* after invagination of scolex.

L. Jarecka Auctor del.

Fig. 4. Egg of *Proteocephalus* sp. (in text not described); Fig. 5. Larva of *Proteocephalus macrocephalus* (C r e p l.); Fig. 6. Larva of *Proteocephalus* sp.

L. Jarecka

Auctor del.

Fig. 7. Eggs of *Hymenolepis macrocephala* Fuhrm.; Fig. 8. Cysticercoid of *H. macrocephala*; Fig. 9. Rostellar hook of cysticercoid of *H. macrocephala*; Fig. 10. Eggs of *Hymenolepis sacciperium* Mayh.; Fig. 11. Cysticercoid of *H. sacciperium*; Fig. 12. Rostellar hook of cysticercoid of *H. sacciperium*.

L. Jarecka Auctor del.

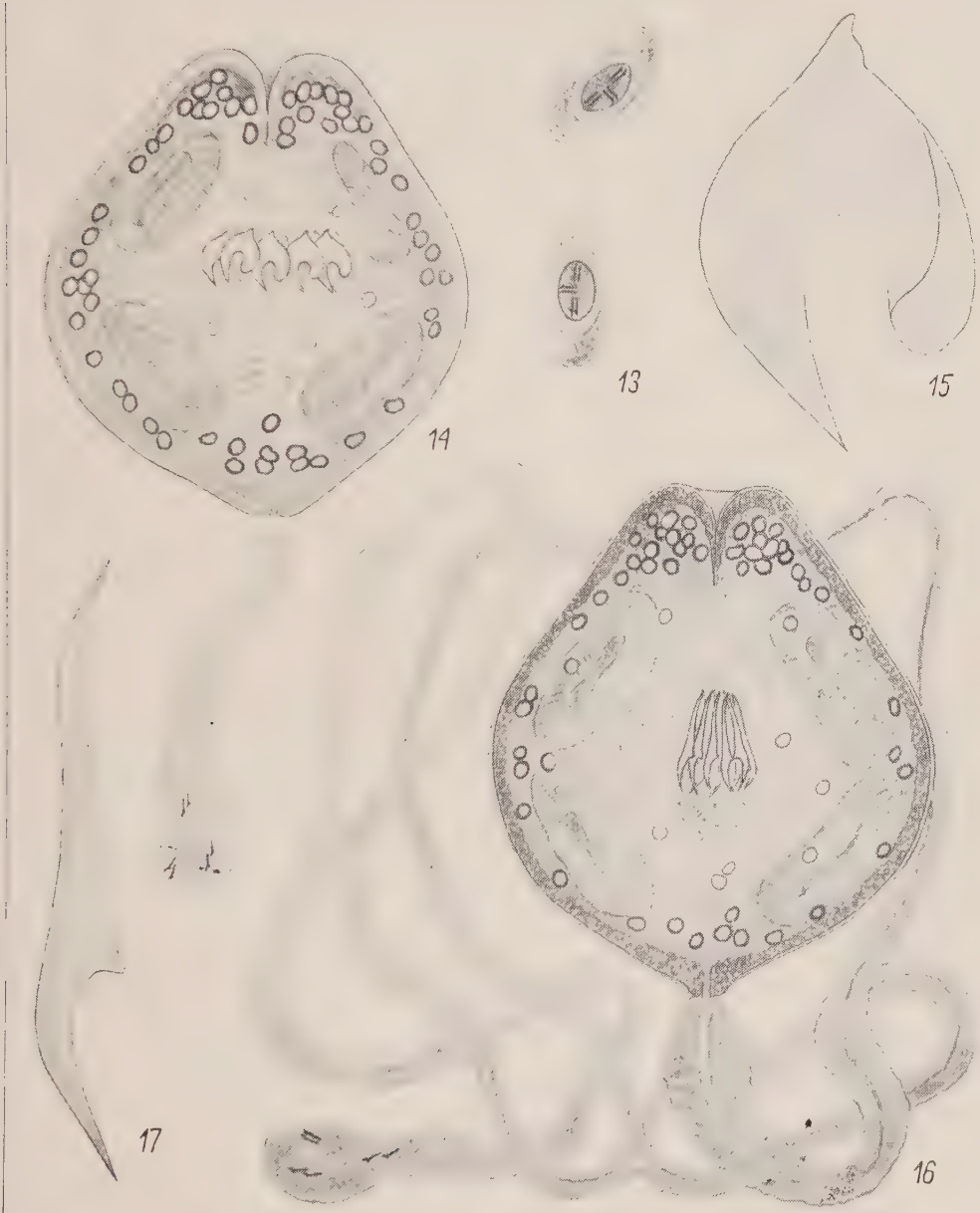
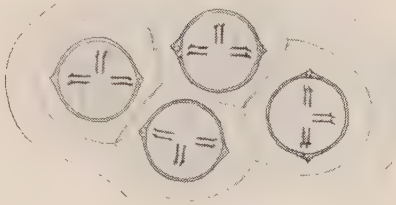


Fig. 13. Eggs of *Hymenolepis aequabilis* (R u d.); Fig. 14. Cysticercoid of *H. aequabilis;* Fig. 15. Rostellar hook of cysticercoid of. *H. aequabilis;* Fig. 16. Cysticercoid of *Drepanidotaenia bisacculina* S z p o t; Fig. 17. Rostellar hook of cysticercoid of *D. bisacculina.*

Fig. 18. Mature segment of *Tatria acanthorhyncha* (W e d l); Fig. 19. Egg of *T. acanthorhyncha*; Fig. 20. Cysticercoid of *T. acanthorhyncha*; Fig. 21. Rostellar hook of mature *T. acanthorhyncha*.

L. Jarecka Auctor del.



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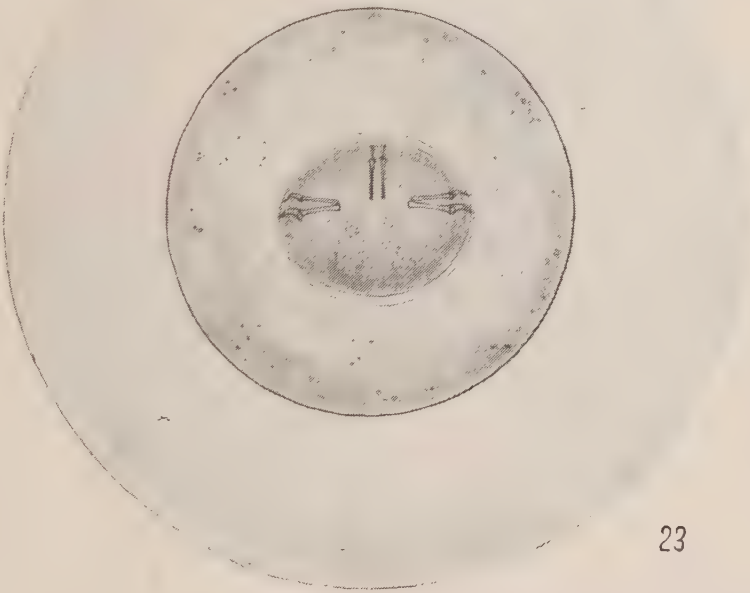

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Fig. 22. Packets of eggs of *Aploparaksis furcigera* (R u d.); Fig. 23. Eggs of *Paricterotaenia porosa* (R u d.); Fig. 24. Embryonal hooklets of medium pair of *Paricterotaenia porosa* oncosphere; Fig. 25. Embryonal hooklets of lateral pair of *P. porosa* oncosphere.

L. Jarecka Auctor del.

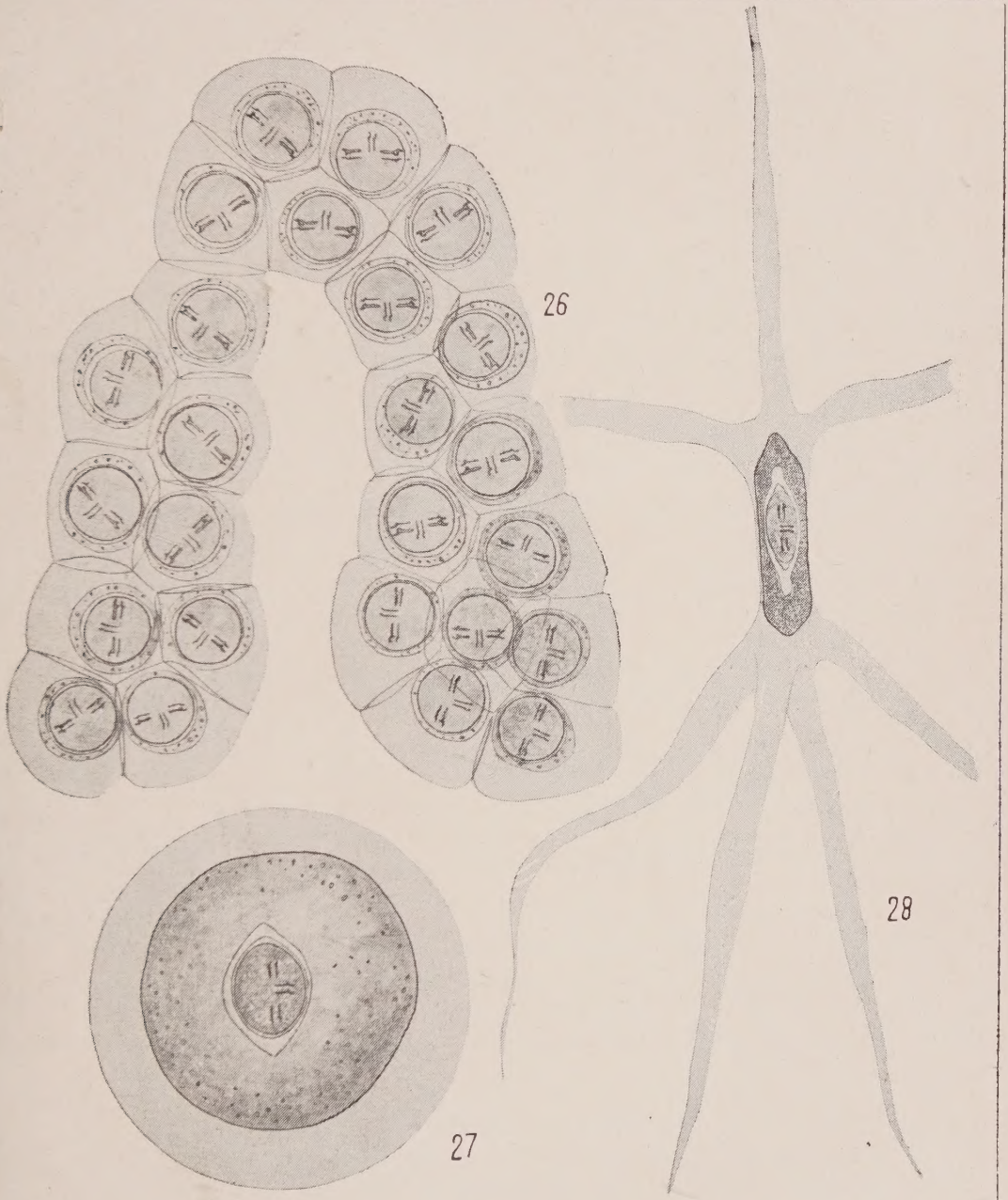

Fig. 26. Packet of eggs of *Hymenolepis abortiva* (Linst.); Fig. 27. Egg of *Hymenolepis compressa* (Linton); Fig. 28. Egg of *Diorchis* sp.

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STRESZCZENIE

Autorka przedstawia dane dotyczące cyklów rozwojowych oraz podaje opis jaj i larw następujących gatunków tasiemców: *Proteocephalus percae* (O. F. Müller, 1780), *Proteocephalus macrocephalus* (Creplin, 1825), *Proteocephalus* sp., *Hymenolepis aequabilis* (Rudolphi, 1810), *H. macrocephala* (Fuhrm., 1913), *H. compressa* (Linton, 1892), *H. abortiva* (Linstow, 1904), *H. sacciperium* Mayhew, 1925, *Drepanidotaenia bisacculina* Szpotańska, 1931, *Diorchis stefańskii* Czapliński, 1956, *Aploparaksis furcigera* (Rudolphi, 1819) i *Tatria acanthorhyncha* (Wedl., 1855).

Dla *Paricterotaenia porosa* (Rud., 1810) i *Diorchis* sp. autorka podaje tylko opis jaj.

Cysticerkoidy: *Hymenolepis spiralibursata* Czapliński, 1956, *H. paracompressa* Czapliński, 1956, *H. gracilis* (Zeder, 1803), *Dicranotaenia coronula* (Duj., 1849), *Diploposthe laevis* (Bloch, 1782), *Fimbriaria* sp., *Diorchis nyrocae* Yamaguti, 1935, *Diorchis inflata* (Rud., 1819), *Diorchis ransomi* Schultz, 1913 w zarażeniu naturalnym jezior Gołdapiwo i Mamry Północne występowały w tych samych co na jeziorze Drużno gatunkach *Crustacea* (Jarecka, 1958a).